CURRENT LITERATURE.

BOOK REVIEWS.

Injury to plants by cold.[1]

THE prominent and peculiar feature of this research lies in the direct observation, by the use of the microscope, of the phenomena of freezing. A specially constructed box, with triple walls for the non-conduction of heat and for receiving a freezing mixture, enabled the author to enclose his microscope where objects were frozen during observation. On freezing colloids, emulsions and solutions, Molisch found, as others had found before him, that water, on becoming ice, separated itself from the contained material; but Molisch's microscope showed that the colloids formed a network of denser material, the emulsions formed a network of granules, and the solutions formed a network of concentrated or solid substance. Each of these networks contained ice-masses in the meshes. On thawing, the network disappeared *quickly in some of the liquids, but only slowly in others* such as starch paste, which is permanently altered by the freezing.

The author next experimented with the freezing of living bodies, using amœbæ, hyphæ of *Phycomyces nitens*, yeast, Spirogyra, and other algæ, hairs of Tradescantia, and the guard cells of stomata. The results obtained here are directly comparable with those obtained with merely physical bodies. The protoplasm on freezing became a network of denser material, with lumps of ice in the meshes. The capillary filaments of Spirogyra and Phycomyces gave up much of their water to the formation of an external ice mantle, and ice formed internally only at a temperature many degrees below zero, this being comparable with the well-known fact that ice forms in purely physical capillary tubes only when the temperature is several degrees below zero. The guard-cells of stomata were found to form ice only when considerably below zero; and this phenomenon the author explains by the greater content of dissolved substance in these cells, and by their capillarity.

In the next section of this monograph, Molisch seeks to answer the question as to whether plants die from freezing or thawing. Like Göppert, Sachs and Müller-Thurgau, he has tested hundreds of plants by the slow and by the rapid process of thawing, and like all but Sachs he finds, with the excep-

[1] MOLISCH, HANS.—Untersuchungen über das Erfrieren der Pflanzen. Gustav Fischer, Jena. 1897.

tion of one plant, that the slow thawing does not restore to activity. The sole exception was that of excised leaves of *Agave Americana*. If these were frozen in a not too low temperature, slow thawing restored more cells to activity than did rapid thawing. Göppert's work in using the change in color in the indican-holding blossoms of orchids as a test for the death of the protoplasm, was imitated by Molisch in using three marine Florideæ, Nitophyllum, Gelidium and Plocamium, red algæ which become orange on dying. In this test the orange color always came when the plants froze. The author had previously found that the plant *Ageratum Mexicanum* exhaled the odor of cumarin on dying. He therefore used this plant also as a test, and found the cumarin odor appearing when the plant froze. To the reviewer this work on the Florideæ and Ageratum seems the most important part of the whole paper.

The injury to plants by temperature just above 0° was also studied. Molisch concludes, as others have before him, that in many cases the injury is due to excess of transpiration over absorption of water. In other cases the injury cannot be due to this cause, for it takes place when transpiration is checked by external means. Molisch believes that the injury in such cases is due to a disturbance of the metabolism of the organism, and suggests that there may result the accumulation of some toxic product, or a failure in the production of some necessary substance. Many plants, all from warm climates, were used in obtaining this result. A plant especially sensitive was *Episcia bicolor*, whose leaves became brown and contained mostly dead cells after an exposure of four days to a temperature of 3°. Preventing transpiration, shielding from the light, very gradually changing from a warm to a cold temperature, made no difference. Nearly all the species of plants used died within thirty-five days; a few lived two and one-half months; while two plants of *Philodendron pertusum* lived through the winter in the cold, but suddenly died in the first warm days in March.

Lastly, Molisch comes to the theory of death by freezing. Death comes with freezing, not with thawing, and is due to the withdrawal of water from the protoplasm. Thus Molisch finds himself in complete accord with Müller-Thurgau, who has given us a like explanation. The reviewer is not disposed to object to this conclusion in a general way, but would suggest that there are various phenomena, some of which are mentioned in the present paper, that do not come into harmony with the theory. To mention one of these is enough: Müller-Thurgau has found, and Molisch accepts the result, that the more the temperature is lowered, the more is the ice formed, and consequently the more is the water withdrawn from the protoplasm. Molisch states that wilted plants are less likely to be injured by frost than not wilted. This query, of course, comes: Why, according to the theory of injury by freezing, should not a given low temperature leave as much water in the protoplasm of a turgid plant as in that of a wilted plant?—F. C. NEWCOMBE.